DOCUMENT RESUME

ED 281 204 CS 210 423

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TITLE Teaching the Use of Metaphor in Science Writing.
PUB DATE Mar 87
NOTE 25p.; Paper presented at the Annual Meeting of the Conference on College Composition and Communication (38th, Atlanta, GA, March 19-21, 1987).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Freshman Composition; Higher Education; Learning Strategies; Literary Devices; Metacognition; *Metaphors; Rhetorical Invention; Science Instruction; Technical Writing; Writing Exercises; Writing Improvement; *Writing Instruction; *Writing Processes

ABSTRACT

A freshman writing assignment sequence encouraged students to use metaphors to think their way through scientific topics, improving their writing skills in the process. The students were all women, aged 18 to 48 years, who had been journal writing for several months but who did not consider themselves competent readers or writers. Reading material was chosen for its use of metaphors to explain scientific topics. The writing component began with the students' own sometimes sketchy technical and scientific knowledge. At first, the students simply explored their topics. Later they were required to shift psychologically from the writer's or participant's role to the reader's or spectator's role. This revision stage also included shifting from the transactional to the poetic and from simile to metaphor. The students found that metaphors made a fluent connection between their personal experience and a scientific model, and they were encouraged to reflect on how they had benefitted from the stages of the assignment sequence and to examine their own cognitive growth. In the final stage, they wrote about their rhetorical choices and the thinking strategies they had used. The students agreed that their writing and grasp of the subject matter were improved by the use of metaphorical writing and thinking processes. (Fourteen references are included.) (AEW)

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# TEACHING THE USE OF METAPHOR IN SCIENCE WRITING

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# TEACHING THE USE OF METAPHOR IN SCIENCE WRITING

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> "We often think, naively, that missing data are the primary impediments to progress -- just find the right facts and all problems will dissipate. But barriers are often deeper and more abstract in thought. We must have access to the right metaphor, not only to the requisite information."
>
> -- Stephen Jay Gould (1985)

Many recent publications acknowledge the importance of metaphor in the development of composing and comprehending skills (Bump, 1985; Geller, 1984; Sacks, 1979, McQuade, 1983). Elliot Eisner, in his "Aesthetic Modes of Knowing" chapter in the 1985 NSSE Yearbook, argues, "The creation of coherence is a central aim in both art and science....If there were a greater appreciation for the extent to which knowledge is constructed--something made--there might be a greater likelihood that its aesthetic dimensions would be appreciated" (1985). Since writing about science is a difficult task for most non-scientists, we have attempted, in writing classes, to help freshmen become more coherent scientific thinkers. We have found, simply, that when students use metaphor to think their way through scientific topics, they become better writers. They communicate knowledge rather than state impressions. Their intellectual commitments to their subjects seem

deeper, and when given the chance to reflect on their methods, they understand how their writing improves.

One of the fundamental principles of language development to arise from the research of James Britton and his colleagues at the University of London Institute of Education was that "language is a highly organized, systematic means of representing experience, and as such it assists us to organize all other ways of representing" (1972). Britton's description of the social development of verbal thought and understanding is essentially an aesthetic description: "We each build our own representation of the world, but we greatly affect each other's representation, so that much of what we build we build in common" (1970).

Implicit in Britton's description is the creative act of representation, an aesthetic conception of language development. Philosophers such as Burke, Cassirer, Lakoff and Johnson, Langer, and Richards have long asserted that the impulse to make metaphors is basic to human consciousness (Geller, 1984). Britton's research seems to confirm that view. Linda Geller's review of the research on the "ontogenesis of metaphoric capabilities" also shows that metaphor use probably follows a developmental scheme (1984).

Lev Vygotsky's insights into adolescents' language development, that language is "sociohistorical" in nature, would seem to indicate that metaphorical thinking is contingent upon instruction (1962). Thus, if metaphor is basic to the human representation of reality, instruction in the use of metaphor would be essential to any English curriculum which purports to teach "thinking." As Ernst Cassirer has stated: "If

this is indeed the case--if metaphor, taken in this general sense, is not just a certain development of speech, but must be regarded as one of its essential conditions--then any effort to understand its function leads us back, once more, to the fundamental form of verbal conceiving" (1962).

Jerome Bump's article, "Metaphor, Creativity, and Technical Writing" (1985), reveals the need for a mechanism to teach the use of metaphor in scientific and technical writing, especially for the non-scientist and the non-technician. He makes his case thoroughly, citing the lack of current research, texts, and instruction. But Bump does not discuss classroom instruction in scientific writing and thinking, nor does he deal with the key issue of teaching the metaphor itself. He also appears more rhetorically than cognitively oriented in his discussion. We are concerned with both modes, because one supports the other.

Scientists constantly use metaphors for understanding concepts, usually originally represented in the metaphor of mathematics (e.g., mass, energy, relativity). And, they typically translate scientific/technical ideas into verbal metaphor when communicating with non-technical audiences ("black holes," light "waves," computer "memory"). Science is not just technical understanding any more than writing is merely knowledge of formal grammar. As Bronowski suggests, "The symbol and the metaphor are as necessary to science as to poetry" (1965).

The classroom assignment sequence that follows is not only about making metaphors, but about thinking metaphorically. Students use

metaphor as more than just a rhetorical device. Metaphor serves a heuristic function for them. The assignment is designed to do the following:

1. structure the student's thinking via carefully chosen readings and via strategies designed to sharpen her writing each time she revises.

2. offer her "medial guidance" throughout her exploration of a scientific topic.

3. encourage a cognitive shift from writer (participant role) to reader (spectator role) as she begins to sense her audience.

4. produce the shift from simile to metaphor by moving her from expressive, through transactional, to poetic discourse.

[insert figure 1: "What Happens on The Page"]

Prewriting: Readings, Journal Responses, and a Guided Worksheet

Students read essays by noted science writers first. Later, they read their own and each others' essays, arranged in a sequence so that they can examine their writing with the same criteria they used to analyze the models. Readings come from an across-the-curriculum reader, Fields of Writing (1984), and are chosen for their use of metaphor to explain scientific topics. Essayists and scientists such as Darwin,

Einstein, Oppenheimer, Asimov, Eiseley, Thomas, Gould, Lawick-Goodall, Seltzer, and Hoagland have offered science to the general public through compelling and poetic writing, often by employing analogy and metaphor to explain new ideas.

During the weeks they spend on this assignment, students read the models and respond in journals to eight very specific questions for each reading. Most of the questions are rhetorical, examining author, topic, audience, purpose, voice, style, and form. The other questions ask the student to check the author's research choices (primary and secondary sources, explanation of observations), and examine the author's comparisons (how he/she uses analogy or metaphor--or both--to explain the scientific phenomenon). Writing answers in their journals, students become sensitive to the rhetorical decisions professional writers make, and they begin their own expressive investigation into writing about scientific topics.

Our choice to start with expressive writing is based on Britton's observations about expressive language; that "the decision to write, to make meaning, to decide on significance is grounded in the experience of the writer" (1972). Our rhetorical objective is common: to investigate and write about an unfamiliar topic by examining prior knowledge and then synthesizing primary and secondary sources. These students have already had several months of journal writing, and they use the standard triad of freshman writing texts: a reader, a rhetoric, and a handbook. They are neither nascent scientists nor budding technicians. They don't consider themselves competent as writers or as readers. Freshmen at a small liberal arts college for women, they grew up in environments that

traditionally discourage females from science careers; their ages range from 18 to 48. Their SAT verbal scores range from 290 to 540 (one scored 640); their majors range from Liberal Arts through Paralegal Studies, Education, and Business.

Since new understanding must be grounded in experience, our writing component begins with the students' existing technical and scientific knowledge, however sketchy it is. In the early stages of writing, the student needs simply to explore her topic. A worksheet provides medial guidance: she plays with her topic using jargon, analyzes vocabulary words, interviews people who know about it, describes people who don't know about it, reads about it, arranges it into sets and subsets, outlines, maps and diagrams it, lists its uses, and then, finally, tries to compare it to something else. Writing the first draft moves her through an unfamiliar topic via a familiar focus. In the later stages, she redrafts in light of explicit objectives, and polishes with specific strategies.

Julie, a marketing major, wanted to write about the nervous system; specifically, the pathways of the spinal column. She looked up "anterior," "posterior," "lateral," and several other related vocabulary words, studied their definitions and derivations, then researched with a few readings and an interview. She began to "map" what she had learned, and saw that her concept suggested a two-way flow. Later, in reflecting on her thinking, she explained how she decided to compare the nervous system's pathways to traffic:

> The next step was to decide on a target audience...I thought of my sixteen year old brother who had just gotten his license. By using roads, he would have a better understanding of the functions of the spinal cord.

Julie wrote her first draft when she finished the worksheet. At this point, she had moved successfully from expressive discourse to transactional. She had communicated information to a specific audience:

> The major functions of the spinal cord are carrying sensory impulses from the brain down to the muscles and glands of the body, and also carrying sensations such as heat, cold, and pain to the brain.
>
> The spinal cord is made up of three columns--the anterior, the lateral, and the posterior. Each of these columns has its own special functions. Try to think of each column as different roadways, each with its own set of rules. It is on these columns or roads that the fibers must travel to reach their destination. Tha anterior and lateral columns are the two-way roads of the spinal cord. The posterior column is the one-way road....

Her first formal draft, although nicely focused, had the research paper look, and the roadway comparison was an analogy, a cut-and-paste construction. Julie had made connections with her audience in mind, but she had not yet completed her thinking. It was useful transactional discourse, but she needed to go further in order to represent the new model she had conceived.

Multiple Drafting: Structuring Thinking

The use of metaphor, especially "extended" metaphor, in writing assumes poetic discourse on the part of the writer. The function of the poetic mode of discourse is representation of experience -- Julie's vision of the spinal column as a network of roads. As Art Young suggests, "The poetic function of written language becomes important when individuals attempt to relate new knowledge to their value systems" (1982).

The category system in our discussion comes from James Britton. His terms "expressive, transactional, and poetic" refer to the functions of discourse and his terms "spectator" and "participant" refer to the psychological stance taken by the writer. Briefly, expressive discourse is that which one does for oneself without reference to an audience; transactional discourse is, as Britton says, "language to get things done," for communicating meaning directly to a specific audience; and, poetic discourse is for the contemplation of experience, where the form of the language can take precedence over the message being communicated. The writer communicating in transactional discourse assumes a participant role; the writer engaging in poetic discourse assumes the role of spectator. To quote James Britton "...the more fully the demands of [the spectator] role are met, the greater the concern for form, for patterning, for organization into a verbal object, a work of art in language" (1977).

These categories become important because they define certain differences in the psychological shift necessary to move from simile (or

analogy) to metaphor. Britton's system provides a theoretical underpinning which may explain why this assignment sequence works. Most science and technology writing is seen in its functional capacity rather than in its capacity for representation and understanding; it is seen as transactional in purpose rather than poetic (i.e., the writer assumes the participant rather than the spectator role). The same is true of most other non-literary forms. Even in the "normal" writing in the English classroom, we tend to emphasize the transactional in our assignments — we ask students to assume the role of participant.

Art Young claims, "Participant writing involves a self-interested part of the writer attempting to accomplish an actual task in a limited world (a lab report, an environmental impact statement) [ed: Julie's paper on the spinal cord]. Spectator writing involves the whole writer attempting to imagine his total world in response to new experience (reading the Communist Manifesto or doing a problem in quantum mechanics)....As Britton says, poetic language is the language of being and becoming" (1982). Thus, there is a need for a shift from participant to spectator to make the move from transactional to poetic. Such a shift occurs in an assignment in which the student approaches metaphorical writing through the use of simile. In moving from simile (analogy) to metaphor, the student must shift psychologically from participant to spectator. In the classroom exercises we describe, the "leap" in the revision stage is the shift from the transactional to the poetic, participant to spectator, simile to metaphor.

Revising: Moving From Participant to Spectator

The key element, moving students to the use of metaphor in thinking through writing, is revising. Many claims have been made for the efficacy of revising writing in the last several years and, in fact, this science writing assignment is an example of deep structural revision using a rhetorical technique. At the same time, it also points to the real complexity in dealing with simile and metaphor in the classroom, which goes far beyond distinguishing between direct or implied comparisions, or using "like" or "as". Metaphorical writing (and probably thinking, as well) appears most likely to occur through revision.

[insert figure 2: "What Happens in the Head"]

When Julie began to re-draft, according to the assignment sheet's directions, she began to recognize some of the limitations of her preliminary work. In other words, she began to be a spectator in her role as the writer. First, she did more research. She conferred with her peers to see what more they needed to know, she talked to a biologist and she read more about the spinal column itself. Then she looked at a driver's license manual for some ideas about roadways. The next draft was more confident, more informed, and more interesting. The spinal column was still "like" a roadway; the paper presented a useful simile. "It took a few drafts to get the ideas to flow easily," Julie later observed, "I found that 'brainstorming' on paper helped a lot when I tried to think of traffic 'slang' to use."

Her cognitive "leap" to poetic discourse came when she used a technique we call the "verb pass." In her commitment to the roadway model, she had re-conceptualized her topic, and was ready to explore the poetic possibilities for fully representing it. She listed traffic words, particularly verbs, and then tried to fit them into the sentences she had written about the spinal column. The "verb pass" freed her from the constraints of the analogy. By her final draft, she had transformed the paper. Here, Julie represents the spinal cord metaphorically, just as she had intended to do:

> Fibers race down the spinal cord carrying sensory impulses to the muscles and glands of the body. Sensations rush up the spinal cord to make their delivery to the brain. The roadways are jammed with vehicles traveling north and south. The columns of the spinal cord are crowded, bumper to bumper, with fibers and sensations cruising up to and down from the brain. To ensure safety we must employ traffic cops; the brain is the traffic cop of the body....

Julie's paper goes on to describe the other columns, those that head north and south, and the posterior, "do not enter" avenue, confused impulses causing accidents, violators paying fines for traveling in one-way areas, and concludes:

> ...If an impulse travels northbound on a southbound column it may require surgery to correct. Therefore, it is wise to take all traffic laws seriously to ensure health.

Another student, Cheryl, mother of a teenager who had tonsillitis, constructed her thinking around the analogy of warfare. In the early stages, Cheryl had tried to research tonsils thoroughly. She discovered a serious lack of information, and it was through her use of metaphor that she came to understand how tonsils function. She reflects:

> I read magazine articles, books by well-known physicians and medical encyclopedias. The data in these secondary sources provided me with basic facts, but was largely outdated and left me with questions I could not resolve from the information given...after two weeks of frustration, I placed a frantic call to Dr.____, one of my primary sources....As I continued my research, the ideal metaphor bacame apparent. I began comparing the tonsils to the Armed Forces, but soon realized that I needed to narrow the metaphor to truly explain the duties of the tonsils. After a few more tries, the tonsils became a platoon of soldiers stationed at the mouth of a river. The use of metaphor made me realize that my information, although accurate, was disorganized. The data bounced uncontrolled from thought to thought like oil on a sizzling griddle. To create a more organized paper I used the metaphor as a controller for direction. The facts about tonsils followed the order produced by the metaphor creating a smoother paper. I was ready to begin my next draft.

In her first draft, Cheryl took three pages to describe soldiers' duties, in peace and in war, and then explained the functions of tonsils. Her final draft shows how she controlled her model through

metaphor, using rhetorical strategies to represent the reality she had discovered:

> Tonsils are a platoon of soldiers strategically positioned as the body's first line of defense against invasion. Stationed at the back of the mouth, they stand ever watchful, ready to ward off enemy attackers and thus maintain the health and security of the body itself.
>
> In times of peace the tonsils busy themselves manufacturing antibodies,called white blood cells, produced and stored for defense purposes should an assault become imminent. The tonsils screen ingested material and act as a trap for detected infectious agents. Without this intricate security system, the hazardous agents might otherwise storm the respiratory and digestive tracts....[she goes on to explain their job in an offensive assault]
>
> ...Historically, doctors across the nation were quick to point an accusing finger at the tonsils. Without ceremony, the tonsils were yanked from their post and stripped of their esteemed position as first line of defense....
>
> ...In bodies where the tonsils had been relieved of duty no advance warning system existed....when finally called to arms, penicillin quickly killed the aggressor, but not before the body was badly beaten in a battle it could not win alone.

> ...Doctors, who once maligned tonsils as traitors, now recognize the important role that the tonsils played in the defense of the body....

Reflecting: Metacognitive Evaluation

One rather important philosophical and psychological distinction between simile and metaphor has been articulated by Jerome Bump (drawing on Paul Ricoeur's work). In a discussion of scientific thinking, he says "the truly innovative scientist often discovers that his subjects must not be regarded as mere mathematical abstractions, and he moves rapidly from the 'as if' of analogy to the 'as being' of metaphor, making increasing ontological commitments to a theoretical model, a sustained and systematic metaphor" (1985). It wasn't until Cheryl saw tonsils as soldiers stationed at the mouth of a river that she answered her own research questions. Through her metaphor, she had made a fluent connection between her experience and a scientific model.

The metacognitive evaluation in the assignment contains the evidence of this connection, or the lack of it, in some student's papers. This third component allows students to reflect on how they benefit ed from the stages of the assignment sequence, to evaluate and document how they paced their writing, and to examine their own cognitive growth. There are two steps in this final phase of the assignment. First, they write an acknowledgements page, based on the need to recognize their sources of help. (Cheryl, for example, thanked her son for suffering the agonies of tonsillitis, her doctor, and

several friends who proofread her drafts.) Then, in their final journal entries (used as part of a final exam), they ask themselves the same eight questions they asked of the professional writers earlier. They write about their rhetorical choices, and they describe the thinking strategies they learned and used.

In their reflections above, both Julie and Cheryl knew that they had achieved metaphorical description through multiple drafts and structured strategies; they had moved from participant to spectator in their representation of science. At this stage, they could "step back" and recognize where they had made the "cognitive leap." Denise, interested in describing how flowers blossom, had read several children's books and a botany text, observed, "My idea came when I made a batch of popcorn and watched the first few kernals popping....I realized that by using popcorn as my focus and a child as my audience, I learned a great deal, not only about writing, but about the process of flowers blossoming."

Some of the students had made choices that did not work as successful metaphors. Pat explains:

> As a writer, I learned the importance of focusing early in the research. I understand how the metaphor can control the focus; however, in trying to make my metaphor work, I unconsciously shifted my focus....Once involved, I never stopped thinking--thinking of every aspect of swimming pool maintenance that related to diabetes. In the thinking involved in this assessment I'm still learning. The first and last paragraphs were

> metaphorical, but they now appear disjointed from the body of the paper....I was disappointed in the end result of my paper, but I do not feel I could take it one step further. The metaphor does not work. I learned from my mistakes and my accomplishments.

Marybeth, who works in a health club, chose to describe a tanning machine by comparing it to a toaster oven, and ended up with a paper using some unintended mixed metaphors: a "shriveled prune hand" squeezing a trigger, long rods "forcing heat upon a helpless body," ultraviolet rays "shooting out of the rods and penetrating the skin." She knew that she hadn't gone beyond inadequate analogy, that her paper was confused: "I tried to show how a tanning machine was like a toaster oven....My descriptive thinking stayed the same, and I had to change my thinking only one way...to explain one thing I needed to use another."

Even when students failed to solve the rhetorical problems posed by the assignment, they often achieved greater scientific understanding. Veronica, a jogger, struggled to understand the body's cooling system. She had tried car engines and air conditioners. For several weeks, she had been looking for a way to write about evaporation. She talked to friends and family, to professors and tutors. She knew that with the right metaphor she'd be able to explain how the body cools itself. She refused to give up, and she tested many verbal hypotheses. She wrote in her journal about her thinking and, in the tradition of good science, ended her reflection with a question:

> ...The process is the same for evaporation and the old-fashioned icebox. They both go from one form or state to another and they

> both need energy to do this. Heat is the energy they use...this process is not hard to explain but it is hard to understand because it is a different way to look at it. The more you think of it the more it makes sense. Now the question is: does the food stay cold because the ice takes the heat away so it can melt or does the ice melt because the food gives off heat?

Although Marybeth and Veronica never achieved the same quality of metaphorical description as Julie ar Cheryl, both became aware of ways to improve their thinking. In any case, all of these students learned about rhetoric and research. Unlike other freshmen writers, they did not change their topics or blame the library. They tried new strategies for structuring their own reading and writing. Although their attitudes toward science had improved, it was clear to them that science was not the main purpose of this assignment, but that both metaphor and analogy are fundamental elements of thinking. Previous achievement (or failure to achieve) did not predict success (or failure) in this exercise. Not only were "good" students forced to re-evaluate their own habits, but students who often failed because of purely mechanical deficiencies were freed to work out their problems and achieve success--to their delight. Many students were surprised that they drafted so many times, stayed with a difficult topic and wrote so effectively.

Conclusion

Finally, though, how important is poetic discourse if students need the "real world" writing skills promised by transactional writing? As

Art Young points out, citing James Britton: "practice and facility in writing poetically may indeed increase a writer's effectiveness in writing transactionally" (1982). So there need not be an "either/or" choice in the decision to write in the poetic mode, even in technical writing classes. In other words, students' expository essays will be improved directly and indirectly by the use of metaphorical writing and thinking exercises. The school writing most of us focus on is improved by the seemingly less "practical" activities suggested here. Classroom practice that includes attention to poetic discourse (not to be confused with the expressive discourse which passes for what we loosely call "creative writing") is an essential part of the verbal thought development of our students.

Once again, this assignment sequence is not only about making metaphors, but about thinking metaphorically. We are following in the tradition of Max Black who claims that, "metaphorical thought is a distinctive mode of achieving insight, not to be construed as an ornamental substitute for plain thought" (1962). Or, more recently, Paul Ricoeur's idea that "in service to the poetic function, metaphor is that strategy of discourse by which language divests itself of its function of direct description in order to reach the mythic level where its function of discovery is set free" (1977).

Cheryl's experience with this assignment had informed her enough to make a real-life scientific decision. In her final journal entry, she explains:

> When I began to consider my audience, I chose a dramatic lead to grab the reader's attention. Parents are busy and need to know immediately if the subject is of interest to them....To keep the reader's attention I opted for an informal approach, comparing the duties of the tonsils with terms that could be easily understood by anyone who has seen war movies, had a spouse in the service, or watched news clips about battles in the Middle East....I expected this research to confirm my suspicion that Frank's tonsils should be removed, but the opposite has occurred. I now know that tonsils serve a useful function and should be retained unless they are so worn from battle that the bacteria sees them as easy prey and attacks incessantly.

Together, at the end of the semester, Cheryl and her doctor decided not to remove Frank's tonsils.

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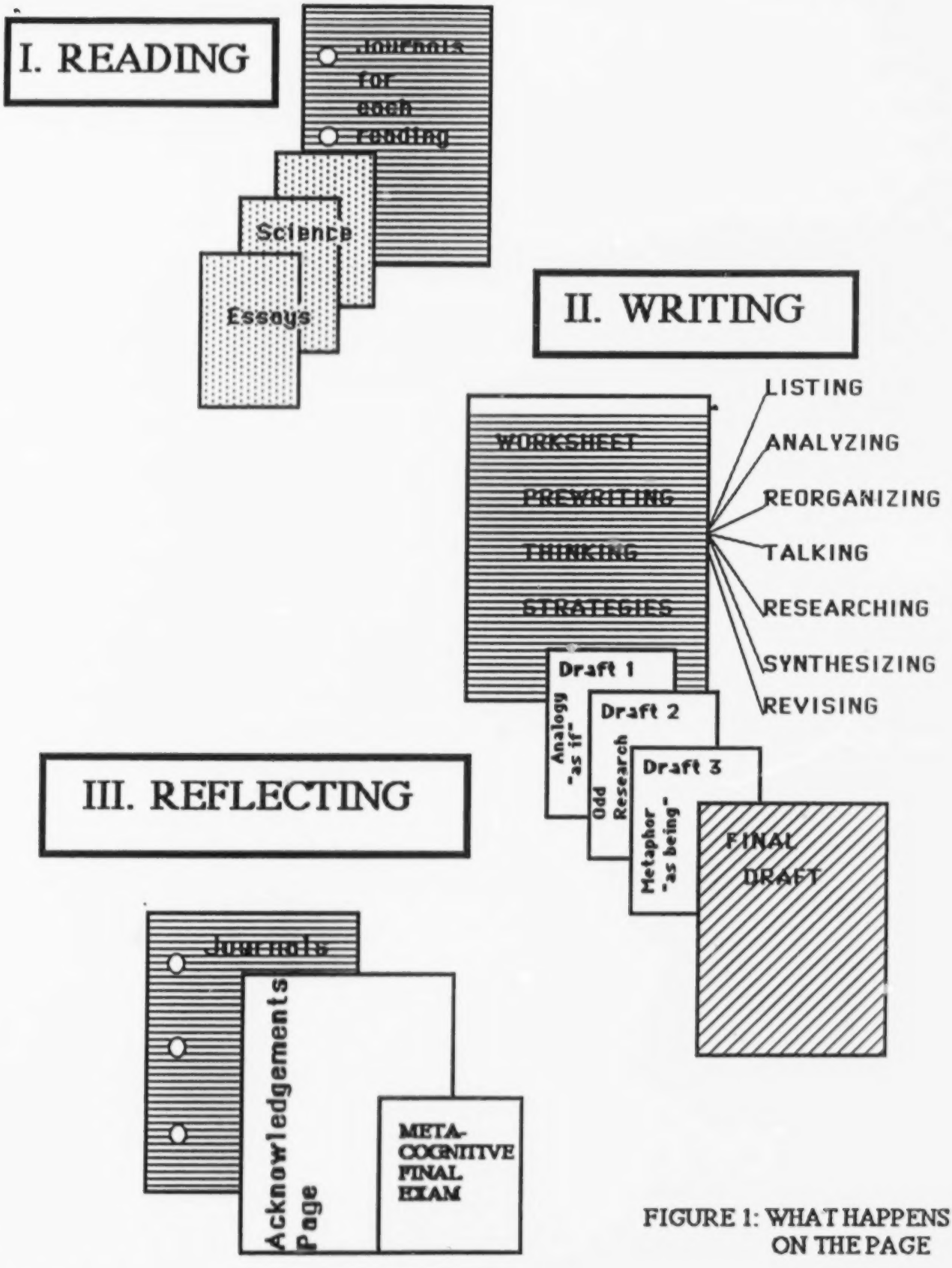


FIGURE 1: WHAT HAPPENS ON THE PAGE

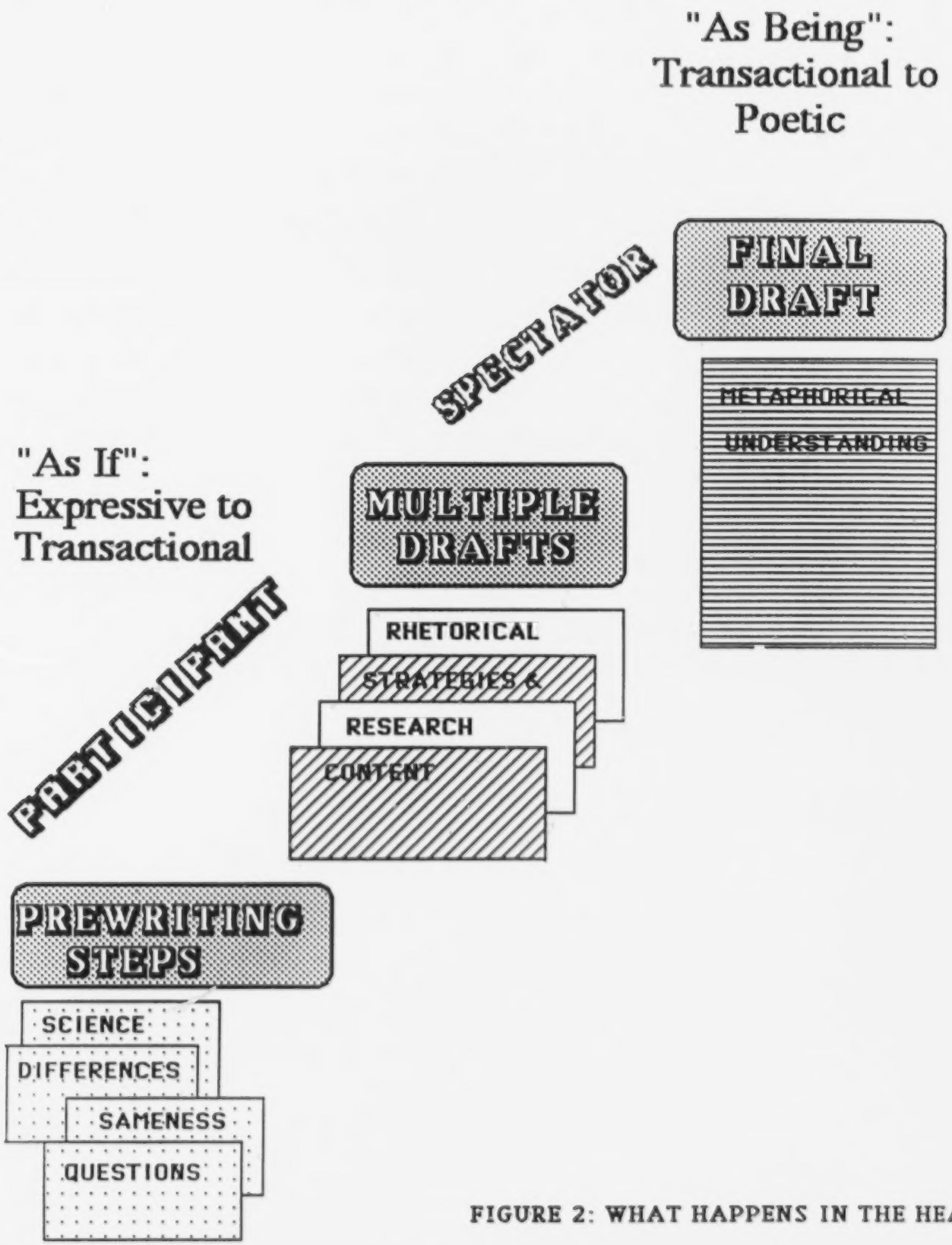


FIGURE 2: WHAT HAPPENS IN THE HEAD